Identifying the key success factors for the adoption of mobile learning

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Abstract There is evidence that sustainability and efficiency are challenges for mobile learning adoption methods. The objective of this study is to identify, categorize and evaluate the critical factors that shape the adoption and sustainable use of mobile learning.. The study will investigate the factors that affect mobile learning adoption, how they can be categorized and what is the prioritization of these categories in the context of Catalonia. The research in this study was designed according to a mixed methods paradigm applying a mixed research approach weighted toward quantitative data, including a literature review, a systematic review, and an expert judgement. A total of 361 factors were identified by reviewing 74 studies; twenty-six studies were included in the systematic review; and seven Catalan experts participated in the expert trial, including three school leaders, two university experts and two education inspectors. This study provides a taxonomy to categorize and orchestrate the factors affecting the adoption of mobile learning providing a holistic and coherent vision. . This categorization contributes to improving sustainability in the adoption of mobile learning. Overall, participants prioritize the five categories from the most challenging to the lowest impact as follows: leadership; personal character, attitudes, and ethics; digital literacy; pedagogical; and technological resources. The major limitation of this study is the lack of contextualization of the proposed categorization. Future research should offer different perspectives in order to generalize the results. Findings may vary with technological advances. The findings are expected to be useful both in academia and for school stakeholders as insights for further research and efficient and sustainable mobile learning adoptions.

Keywords Adoption factors . Mobile learning ·Success factors .Technology integration

1.Introduction

1.1 Theoretical framework

The steadily advancing digitalization of our world and the growing demand for digital talent requires changes in the educational systems. requires educational changes. Mobile learning is a learning framework with great potential within and outside of the classroom. Millions of jobs could be phased out, the day-to-day nature of work could change for nearly everyone as intelligent machines become fixtures in the workplace (Lund et al. 2019).. Schools face the significant challenge of having to develop learning experiences to prepare students for the labor market, even if half of the jobs are expected to disappear in the future. More than 60% of all jobs require a high level of critical thinking, creativity, and interpersonal skills (Horn 2014). In this context, there is a need for innovation toward the future of education, and digital approaches have a significant role. There is a consensus among different key frameworks for 21st century skills that digital will play a significant role (Esteve 2015).

Affordability and usability are progressing worldwide. The U.S.-based technology company Cisco predicts that, by 2021, there will be 27.1 billion Internet-connected devices three times the global human population. Mobile device penetration levels will continue to grow, and the Bring Your Own Device (BYOD) model seems likely to become the norm. There are multiple studies reporting positive results when BYOD is applied to enhance learning and engagement (Song and Wen 2018). Usability and functionality are constantly evolving. For example, (Hochberg et al. 2018) demonstrated how built-in sensors incorporated in smartphones have multiple advantages for teaching and learning by using smartphones as experimental tools.

There are numerous mobile learning definitions, most of which highlight core characteristics and affordances. Danish and Hmelo-Silver (2020 grouped and analyzed the affordances of mobile learning in four categories: (1) multiple contexts, (2) social interactions, (3) content interactions, and (4) capturing information and providing that information in real-time. Grant (2019) used another categorization to group the characteristics of mobile learning: (1) relationship to distance education and eLearning,

(2) exploration of devices and technologies, (3) mediation with technology, and (4) nomadic nature of learner and learner.

A vast literature has demonstrated multiple positive benefits and impacts of mobile learning, and mobile learning is recognized as one of the most influential technologies for education (Chee et al. 2017; Crompton and Burke 2018; Hwang 2014; Islam and Grönlund 2016; M. Liu et al. 2014; Mahdi 2018; Moya and Camacho 2020; Pimmer et al. 2016; Sung et al. 2016; Vieira et al. 2018; Virtanen et al. 2018; Wu et al. 2012; Zheng et al. 2018).

The frameworks that have been developed to implement mobile learning focus on technology, content and pedagogical aspects, the purposes of which were mainly design and development tools, analysis tools, and evaluation and guiding tools (Al-Hunaiyyan et al. 2017; Bikanga Ada 2018; Crompton 2017; Hwang 2014; Kearney et al. 2012; Koole 2009; Lim Abdullah et al. 2013; Ng and Nicholas 2013; Nordin et al. 2010; Park 2011; Rikala 2015; Veerabhadram and Lombard 2019). However, a considerable number of schools are still in the early stages of mobile learning adoption (Alrasheedi and Capretz 2015; Kopcha 2012; Niemi et al. 2013; Park 2011; Rikala 2015; Stevenson et al. 2015; Veerabhadram and Lombard 2019). Moreover, when technology integration occurs, sustainability and efficiency are challenges for mobile learning adoption methods (Sutton and DeSantis 2017). There is evidence of a gap between the availability of technology and effective use in classrooms. Primary and secondary education is still far from maximizing digital potential and developing in students the competences of the global digital challenge. According to the Teachers Teaching and Learning International Survey (TALIS) 2018 report (OECD 2020), only 43% of teachers declare to be prepared or very well prepared for the use of technology in teaching, the lowest grade of all the dimensions evaluated. In Europe, the average is significantly higher than 50% and in the case of Spain, it drops to 38%.

Often, the challenge in adopting technology is focused on acceptance or rejection by people (Davis 1989; Hamidi and Chavoshi 2018). Many theoretical frameworks have been created to test user behavior, and several models were identified during this research. Among the different models, Technology Acceptance Model (TAM) appears to be the one most applied in many research fields. The literature shows a broad consensus with regard to considering the adoption of technology to be a strategic process (Aguti et al. 2014; Lim Abdullah et al. 2013; Ng and Nicholas 2013; Peng et al. 2009).

The Department of Education of the Generalitat of Catalonia is implementing the mòbils.edu project, aimed at improving digital skills through the implementation of mobile learning in the last years of primary and lower secondary school, providing training, computers and connections to both students and teachers (‘mòbils.edu’ 2020). Previous experiences did not yield positive results. The first national policy plan for the adoption of technology in secondary schools was the European policy program 1: 1, “School 2.0” of 2009. According to a study by Fraga-Varela and Alonso-Ferreiro (2017) carried out on this project, there was a favorable opinion towards the implementation of the 1 to 1 model in educational centers; however, they reflect a substantial degree of rejection of educational policies and reveal difficulties derived mainly from the lack of information and teacher training.

There are numerous consolidated studies within the field of strategic management that analyze the critical factors that affect strategic processes and group them into categories (Dewar et al., 2011; Guohui & Eppler, 2008; Higgins, 2005; Humaidi, Anuar, & Said, 2010; Peters & Waterman, 2006).

Sustainability is key to the successful adoption of mobile learning. Most studies of mobile learning are short-term, funded projects where access to technical support and pedagogy are often predetermined through sponsorship (Ng and Nicholas 2013). Some authors argue that there is no continuous training (Crompton 2017).

There are many fields in which critical factors are identified and managed as crucial elements in the strategies of the organizations. Critical factors definitions often relate to constructs or activities that must be managed in order to succeed in strategy (Goyal et al. 2010; Jauch and Glueck 1988; Mintzberg and Quinn 2007; Porter 1996).

1.2 Purpose of the study

The objective of this study is to identify, categorize and evaluate the critical factors that shape the adoption and sustainable use of mobile learning conducting a case study. This study considers the adoption of mobile learning as a strategic process of change and therefore includes studies in the field of strategic management. The three specific research questions driving this study are as follows:

(1) What are the critical success factors for the adoption and sustainable use of mobile learning in education, as identified in the main academic publications between 2008 and 2018?

(2) How can the key factors affecting mobile learning be grouped in a hierarchical taxonomy in the education context?
(3) What categories of success factors are given more importance?

The outline of the paper is as follows. Section 1 includes a brief review of the current literature on mobile learning, the objective, and the research questions. Section 2 describes the different methodologies used to approach this research. Section 3 details the main factors affecting mobile learning; a proposed taxonomy and a case study of success factors affecting mobile learning adoption in Catalonia. Section 4 summarizes the discussion. Section 5 concludes.

1 Methodology

This research is developed under an interpretive paradigm in which reality is complex. The different methodologies included in the study combine qualitative and quantitative data to provide a broad interpretation aimed at answering the research questions. The generalization of the results is linked to the context of the study (Guba and Lincoln 1981).

2.1 Research design

Explanatory sequential design (Creswell 2012) was used to direct different methods and mixed collection data tools to triangulate and validate the research and prove evidence. Table 1 illustrates the research design.

Table 1 Research Design

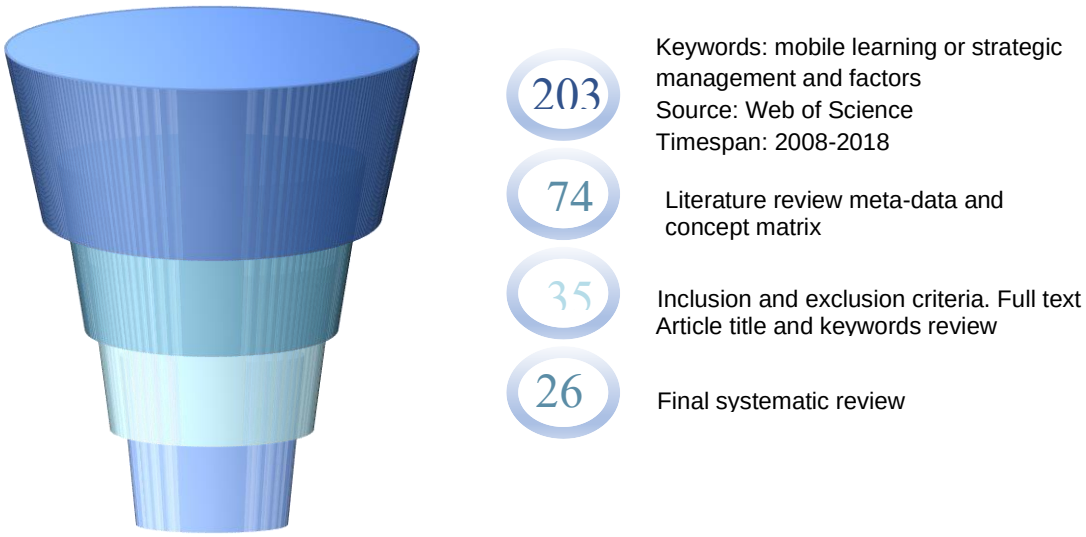
Research objectives	Research Question	Data collection method & Instrument	Sample/ Participants
Develop an initial understanding of key factors affecting mobile learning adoption. What are the key success factors in integrating mobile learning within education?	RQ1	Literature review	n= 74 studies. n= 361 Factors
To collect evidence regarding common barriers and enablers of mobile learning. Identify main categories grouping factors affecting mobile learning adoption. Gather information needed to design the expert judgment research model	RQ2	Systematic review	n= 26 studies
To collect evidence regarding the importance of the most common barriers and enablers of mobile learning in Catalonia. To explain and validate the findings from previous research	RQ3.	Expert Judgement	n= 7 experts

2.2 Literature review and systematic review

The literature review was based on a concept-centric approach (Okoli and Schabram 2010; Webster and Watson 2002). Based on the extended consideration of mobile learning adoption as a strategic process, as described in the theoretical framework of this study, both the mobile learning and strategic management critical factors were included in this research. The results were filtered by timespan between 2008 and 2018, resulting in 203 studies. A total of 74 studies were selected based on titles and the reading of their abstracts.

For the systematic review, the protocol proposed by Okoli & Schabram (2010) has been followed. This guide is aimed at structuring and organizing the systematic review of literature through the process consisting of four phases: (1) planning, (2) selection based on inclusion criteria, (3) data extraction, and (4) analysis. The first step requires to identify the purpose of the research, the main purpose of this study is to identify and evaluate the critical factors that shape the adoption and sustainable use of mobile learning. Second phase focuses on the review of the literature and practical screen that have been addressed in the previous section. The inclusion and exclusion criteria necessary to execute the third phase are detailed below.

Inclusion criteria: mobile learning or M-learning integration or adoption were among the key variables of the study, categorization or grouping was among the key variables, and studies must have been published between 2008 and 2018. The database used has been Web of Science recommended for literature reviews in relation to education (Fu & Hwang, 2018). A total of 35 full texts were identified as eligible for the review and were comprehensively analyzed by both authors. Exclusion criteria determine the quality



appraisal: studies are based on academically relevant methodologies; provide research in real learning contexts; and published in prestigious journals in the field of mobile learning. Finally, 26 studies were included in the systematic review. Fig. 1 shows the data search and collection process.

Fig. 1 Diagram of the systematic review search process

The fourth phase of the systematic review protocol proposed by Okoli and Schabram (2010) consists of data extraction. The main information that has been extracted from the studies analyzed are the factors that affect the adoption of mobile learning and its categories. This information together with the metadata of the studies has been synthesized and structured in a metadata table.

Table A.1 in Appendix A shows the final pool of studies used in this study. The average publication year of the 26 studies is 2013. Although many recent studies conclude that Asia leads in scientific publications on mobile learning (Crompton et al. 2019), Europe is the leading region among the studies included in the systematic review, as shown in Fig. 2. Table 2 shows the data collection methods, theories and sample size of the publications included in this research. The most common data collection method is the questionnaire – 12 out of the 26 studies used questionnaires. The most used theory is the TAM (Davis 1989).

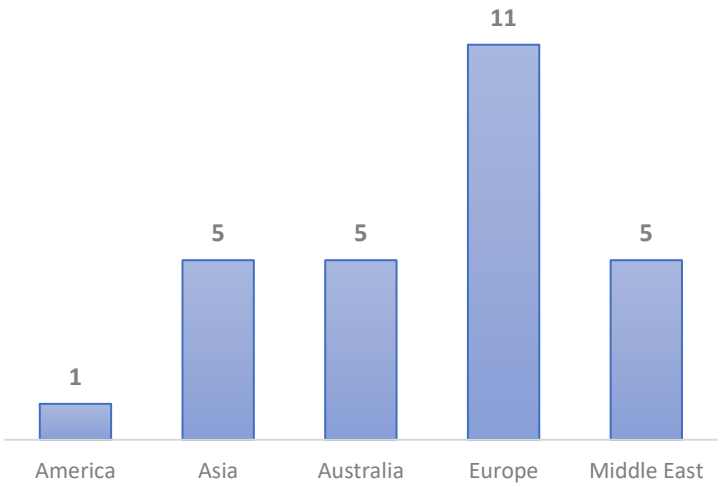


Fig. 2 Geographical distribution by the number of articles

Table 2 Data collection methods, theories and sample size used in this research

Study	Theory	Methodology/Data collection	Sample
(Aguti et al. 2014)		Survey experts	16 experts
(Alrasheedi and Capretz 2015)		Meta-analysis	19 studies
(Al-Sharhan et al. 2010)		Literature review	
(Bower et al. 2015)		Case study	
(Cochrane and Bateman 2010)		Analysis of previous studies/reports	
(Ekberg and Gao 2018)		Semi structured interviews	
(Gao et al. 2011)	TAM	Review and survey pilot test	25 students
(Goyal et al. 2010)		Questionnaire	401 Students 57 and Teachers
(Hamidi and Chavoshi 2018)	TAM	Questionnaire	300 Students
(Hao et al. 2017)	TAM	Questionnaire	292 Students
(Kukulska-Hulme 2008)		Literature review	
(Y. Liu et al. 2009)	TAM	Questionnaire	209 Students
(López-Hernández and Silva-Pérez 2016)	UTAUT	Questionnaire	411 Students
(Lu and Viehland 2008)	TAM	Questionnaire	180 Students
(Mahdi 2018)		Meta-analysis	16 Studies
(Mercader 2018)		Questionnaire	164 Teachers
(Rikala 2015)		Thesis	
(Sabah 2016)	TAM	Questionnaire	80 Students
(Sarrab et al. 2016)	TAM	Questionnaire	806 Students
(Spector 2013)		Analysis of previous studies/reports	
(Stacey and Gerbic 2008)		Literature review	
(Tay et al. 2013)		Questionnaire	Teachers, students, and parents
(Teoh 2011)		Analysis of previous studies/reports	5 Studies
UNESCO (2011)		Report	
(Yadegaridehkordi et al. 2013)	TAM	Questionnaire	350 Students
(Yeap et al. 2016)	TAM	Questionnaire	900 Students

2.3 Expert judgment

Expert judgement was used to answer the third research question. The research was conducted in the context of Catalonian secondary schools in spring 2018. According to Generalitat de Catalunya, Xarxa Telemàtica Educativa de Catalunya, in 2017, Catalonia had 1,146 secondary schools. The Catalan education system enrolls approximately 500,000 students and employs 45,000 teachers.

The expert judgement process mainly focused on discussing uncertainty and understanding impacts across fields (Ashcroft et al. 2016). The three different fields represented were scientific, schools, and government, as represented by academic experts, school leaders and inspectors. Expert judgment took place in Universitat Rovira I Virgili in Spain. Participants in the expert judgment were selected from different backgrounds in education in order to better understand the context in which the data were collected. The selection of experts was carried out considering the aspects highlighted in the study by Ashcroft et al. (2016): expert judgment should be based on the experience of people, with

an experiential and holistic vision. The average years of experience of the experts was 18 years, all participants had participated in numerous communications in the field of education and had a holistic vision. A total of seven experts participated in the expert judgement following the recommendations of (Bisquerra 2004)Bisquerra, who recommends a number between 5 and 10. It is also important to include individuals representing the spectrum of thought on a topic, if there may be different approaches or paradigms (Wilmot and Galson 2000). Three participants were school leaders, two were educational inspectors, and two were university experts. Participants included two males and five females. The transcript was developed from digital recordings. Appendix B, Table B.1 summarizes the Expert Judgement protocol. The experts received a dossier in advance that contained the objectives and basic aspects of the meeting, a copy can be accessed in Appendix B. The meeting took place on February 20, 2018 and lasted 90 minutes. One of the researchers acted as moderator and the other collected information and evidence. Different sources of evidence were gathered such as dossiers, video, photographs, and observation notes. Experts completed and handed their dossiers, which were manually entered into a data table. The statistical package SPSS has been used for the analysis of results.

2 Results

3.1 Factors affecting mobile learning

The literature highlights isolated recurrent factors affecting strategic management and mobile learning. Most of the studies analyzed were focused on the perceived performance or learning outcomes. A significant number of the studies analyzed were focused on students' or teachers' perceptions. Based on the literature review of 74 studies, 361 different factors have been identified.

The most cited factor is communication, which was cited in 10 studies; followed by leadership, highlighted in 6 studies; and assimilation with curriculum and institutional support were cited in five and four studies, respectively.

3.2 Taxonomies of factors affecting mobile learning.

There has been considerable debate about the use of performance management tools in education, the literature shows that there are more examples demonstrating their value than there are detractors (Hernández-Ramos 2014; Ng and Nicholas 2013; Nikolopoulou

and Gialamas 2016). To identify the categories that affect the adoption of mobile learning, this study takes as a reference the categorization of factors that affect strategic management.

There is significant consistency among the grouping of the factors affecting strategic management in two big categories. On the one hand are hard factors, including those impacting company performance in a way that companies can reasonably handle, manage, and measure. This category includes factors such as technological resources, a company's structure, managerial skills, strategy, and organization.

On the other hand, there are soft factors. This category includes the factors affecting the company's soul, culture, and organizational behavior in three main areas: individual, group and organization. Table 3 summarizes the different studies that have identified categories of factors affecting strategic management.

Table 3 Categories of factors affecting strategic management process: frameworks and studies

Category	Study working	Framework	Study
Hard	Hard	7 S framework	(Peters and Waterman 2006)
	Hard	8 S framework	(Higgins 2005)
	Performance	5 As framework	(Dewar et al. 2011)
	Independent	Knowledge Project Management Performance Assessment	(Humaidi et al. 2010)
	Hard	A framework of strategy implementation research	(Guohui and Eppler 2008)
Soft	Soft	7 S framework	(Peters and Waterman 2006)
	Soft	A framework of strategy implementation research	(Guohui and Eppler 2008)
	Soft	8 S framework	(Higgins 2005)
	Health	5 As framework	(Dewar et al. 2011)
	Dependent	Knowledge Project Management Performance Assessment	(Humaidi et al. 2010)

In the field of mobile learning, A. Khan, Al-Shihi, Al-Khanjari and Sarrab (2015) conducted a study reviewing the programs for the adoption of mobile learning in six countries and highlighted two constrains for mobile learning adoption: the technical and non-technical consists.

Together with the categorization of factors that affect strategic management, to identify the categories that affect mobile learning, this study is based on the variables used in the TAM theory of the academic documents included in the systematic review.

As anticipated in the theoretical framework, Table 2 indicates that TAM (Davis 1989) is the most used theory. Nine studies included in the systematic review applied the TAM approach. Fig. 3 shows the TAM diagram.

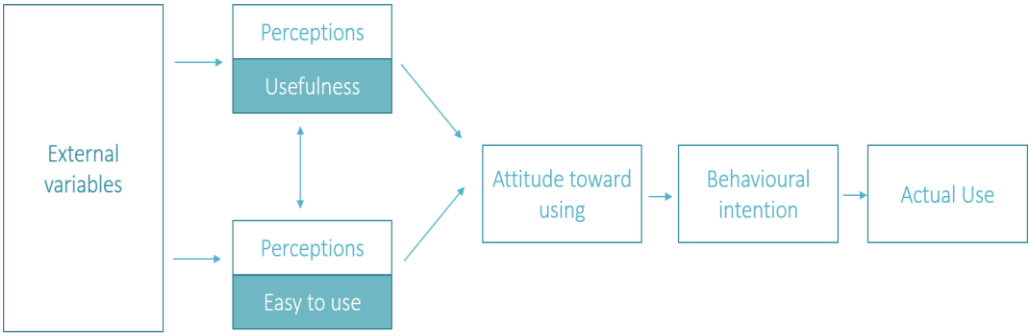


Fig. 3 Original variables in TAM and their relationship (Davis 1989)

All nine of the studies analyzed adopted the original TAM theory specifying the external variables or the additional relationships between factors. Tabled 4 shows the different adoptions made by the studies analyzed in this systematic review.

Table 4 TAM adoptions included in this research

TAM diagram area	Factors	Study
External variables	Context	(Gao et al. 2011)
	Context factor	(Hamidi and Chavoshi 2018)
	Control variables	(Sabah 2016)
	Economic	(Sarrab et al. 2016)
	Enjoyment	(Sarrab et al. 2016)
	Image	(Hao et al. 2017)
	Moderator variables	(Sabah 2016)
	Perceived financial resources	(Lu and Viehland 2008)
	Perceived mobility value	(Yadegaridehkordi et al. 2013)
	Prior use of e-learning	(Yadegaridehkordi et al. 2013)
	Prior use of electronic learning	(Lu and Viehland 2008)
	Self-efficacy	(Lu and Viehland 2008)
	Social	(Sarrab et al. 2016)
	Subjective norm	(Hao et al. 2017); (Lu and Viehland 2008)
	Suitable	(Sarrab et al. 2016)
	Voluntariness	(Hao et al. 2017)
Perceived	Ease of use	(Hao et al. 2017; Y. Liu et al. 2009; Lu and Viehland 2008; Sabah 2016; Sarrab et al. 2016; Yadegaridehkordi et al. 2013; Yeap et al. 2016)
	Innovativeness	(Hao et al. 2017)
	Instructor Readiness	(Yeap et al. 2016)
	Learning Autonomy	(Yeap et al. 2016)
	Long term usefulness	(Y. Liu et al. 2009)
	M-learning services (awareness of services)	(Sabah 2016)
	Mobile limitations	(Sabah 2016)
	Neat-term usefulness	(Y. Liu et al. 2009)
	Option leader	(Yeap et al. 2016)
	Perceived facilitation	(Hao et al. 2017)

Perceived Self Efficacy	(Yeap et al. 2016)
Personal characters and features	(Hamidi and Chavoshi 2018)
Personal Initiatives and Characteristics	(Gao et al. 2011)
Personal innovativeness	(Y. Liu et al. 2009)
Self-efficacy	(Yadegaridehkordi et al. 2013)
Social influential	(Sabah 2016)
Student Readiness	(Yeap et al. 2016)
Subjective norm	(Yeap et al. 2016)
Trust factor	(Hamidi and Chavoshi 2018)
Trust The user's beliefs	(Gao et al. 2011)
Usefulness	(Hamidi and Chavoshi 2018; Hao et al. 2017; Lu and Viehland 2008; Sabah 2016; Sarrab et al. 2016; Yeap et al. 2016)

From the analysis of the rest of the 17 studies included in this systematic review, we can identify five categories that have been recurrently used to categorize the factors.

Technological resources: the first category is related to technological resources and includes factors such as technological infrastructure, navigation, internet connection, mobile tools, level of integration, technical support, student-device ratio, or hardware. The most common ways to refer to this category are: Affordability (UNESCO, 2011); Appropriate choice of mobile devices (Cochrane and Bateman 2010); Device (Kukulska-Hulme 2008); Information and Communication Technology (ICT) infrastructure (Rikala 2015); Infrastructure component (Al-Sharhan et al. 2010); Mobile limitations (Sabah 2016);Physical and technological infrastructures (Tay et al. 2013); Quality e-learning systems (Aguti et al. 2014); Smart Classroom (Al-Sharhan et al. 2010); Smart School (Al-Sharhan et al. 2010); Technological (Goyal et al. 2010); Technological aspects (Bower et al. 2015); Technological factors (Mahdi 2018; Teoh 2011); and Technology (Alrasheedi and Capretz 2015).

Pedagogical factors: the second category encompasses pedagogical factors, such as classroom integration, adaptability of the course, assessment, availability of content and software, critical thinking, thinking development, time management, recognition of informal learning, defining target learner groups for m-Learning, teaching preparation, design approach, gamification, virtual environments, and customization. It is the most cited category among the studies analyzed. The following concepts are included in this category: Curriculum (Rikala 2015); Curriculum and assessment (Tay et al. 2013); Defined target learning groups (UNESCO, 2011); E-content component (Al-Sharhan et al. 2010); E-learning course delivery strategies (Aguti et al. 2014); Learning gateway component (Al-Sharhan et al. 2010); Learning related (Mahdi 2018); Lecture modelling

the pedagogical use of the tools (Cochrane and Bateman 2010); Level of Pedagogical integration (Cochrane and Bateman 2010); Pedagogic considerations (Stacey and Gerbic 2008); Pedagogical (Goyal et al. 2010); Pedagogical aspects (Bower et al. 2015); Recognition of informal learning (UNESCO, 2011); Teaching Pedagogy (Alrasheedi and Capretz 2015; Teoh 2011); Teaching preparation (Ekberg and Gao 2018).

Digital literacy: a third category refers to the educational community's mobile learning skills or digital literacy. To this category belong the following factors: teachers' digital knowledge, training, students' knowledge, teachers' and students' digital competency, and teachers' practices and digital assessment knowledge. Esteve (2015, p. 185) defined digital literacy as the attitude and the ability of individuals to specifically use the tools to identify, access, manage, evaluate, analyse and synthesize digital resources, build new knowledge, communicate, and create new expressions. Several studies identify training as a key category of factors that affect the adoption of mobile learning: Creation of learning community (Cochrane and Bateman 2010); ICT training (Ekberg and Gao 2018); Instructor Readiness (Yeap et al. 2016); Learning Approach (Teoh 2011); Learning approach (Alrasheedi and Capretz 2015); Moderator variables (Sabah 2016); Prior use of e-learning (Yadegaridehkordi et al. 2013); Prior use of electronic learning (Lu and Viehland 2008); Professional barriers (Mercader 2018); Professional development (Rikala 2015); Professional development (Tay et al. 2013); Regarding teachers professional development (Stacey and Gerbic 2008); Student Readiness (Yeap et al. 2016); Teacher (Goyal et al. 2010); Training component (Al-Sharhan et al. 2010).

Personal character, attitudes, and ethics: the fourth category integrates human-related factors, with a focus on individual personal character and ethics. Often labeled as soft or human factors, this category includes behaviors and attitudes, teachers' attitudes, motivation, resistance to change and computer ethics. There is a vast body of literature in the field of computer ethics; the standard approach to computer ethics is to evaluate morally problematic uses of ICT through the lens of different ethical theories and moral philosophies (Jones 2017). This category also includes demographic factors. In their study of mobile learning adoption, Tan, Ooi, Sim, and Phusavat (2012) evidenced the influence on the adoption of mobile learning of demographic factors such as gender, age and past experience. The factors related to ICT anxiety have been repeatedly reported as a significant importance in the adoption of mobile learning (Mac Callum et al. 2014).

Some authors highlighted the importance of understanding cultural limits and the social environment to contextualize this category (Keengwe and Bhargava 2014). Some of the authors analyzed refer to this category using the following expressions: Personal characters, features and ethics; Attitude and knowledge (Ekberg and Gao 2018); Enjoyment (Sarrab et al. 2016); Human use and adoption (Spector 2013); Image (Hao et al. 2017); Individual, social and psychological ; Innovativeness (Hao et al. 2017); Learning Autonomy (Yeap et al. 2016); Perceived financial resources (Lu and Viehland 2008); Perceived Self Efficacy (Yeap et al. 2016); Personal barriers (Mercader 2018); Personal characters and features (Hamidi and Chavoshi 2018); Personal Initiatives and Characteristics (Gao et al. 2011); Personal innovativeness (Y. Liu et al. 2009); Subjective norm (Yeap et al. 2016); Techer's beliefs and practices (Rikala 2015);Trust factor (Hamidi and Chavoshi 2018); Trust The user's beliefs (Gao et al. 2011); User (motivations, demographics, emotions...) (Kukulska-Hulme 2008); Voluntariness (Hao et al. 2017).

Leadership: the fifth category integrates human-related factors, with affecting organizations and groups and highlighting leadership among the most cited. The most cited factor included in this category is communication, collaboration, and cooperation. The following nomenclatures have been included in this category: Leadership; Context (Gao et al. 2011); Context factor (Hamidi and Chavoshi 2018); Contextual barriers (Mercader 2018); Facilitating condition (Hao et al. 2017); Institutional (Goyal et al. 2010); Institutional barriers (Mercader 2018); Institutional success factors (Stacey and Gerbic 2008); Leadership (UNESCO, 2011); Locations (Kukulska-Hulme 2008); Management support (Alrasheedi and Capretz 2015; Teoh 2011); Media and Awareness Campaign (Al-Sharhan et al. 2010); Network (continuity, linkage across contexts...) (Kukulska-Hulme 2008); Option leader (Yeap et al. 2016); Policy and school leadership (Tay et al. 2013); School leadership (Rikala 2015); Social (Sarrab et al. 2016); social influential (López-Hernández and Silva-Pérez 2016; Sabah 2016); Subjective norm (Hao et al. 2017); Subjective norm (Lu and Viehland 2008); Support from educators and parents (UNESCO, 2011); Support from school and leadership (Ekberg and Gao 2018); Technological and pedagogical support (Cochrane and Bateman 2010); Well-defined goals (UNESCO, 2011).

Based on the above analysis, the five categories identified were used to recategorize the 112 categories identified in the 26 studies included in the systematic review. Some

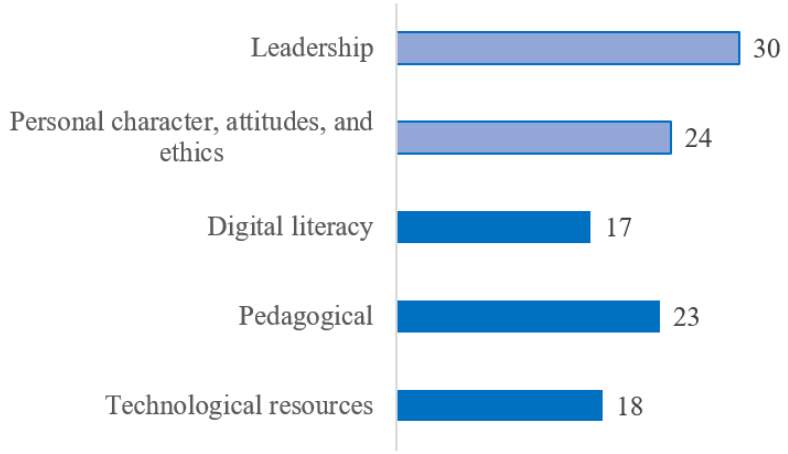
categories fit in more than one group. The classification was reviewed by both authors. Differences in their interpretations were resolved upon discussion. Table C.1 in Appendix C shows the categorization of the factors that affect mobile learning based on the systematic review.

The two groups identified in the critical success factors affecting strategic process (Table 3) were used to position the five categories. Table 5 and Fig. 4 show the dimensions and categories of factors affecting mobile learning adoption and the number of mentions in the 26 studies included in the systematic review.

Table 5 Dimension and categories of factors affecting mobile learning adoption

Dimension	Category	Recurrence in the systematic review
Hard		58
	Technological resources	18
	Pedagogical	23
	Digital literacy	17
Soft		54
	Personal character, attitudes, and ethics	24
	Leadership	30
	Total	112

Fig. 4 Categorization of factors affecting mobile learning against citations



The TAM model has been extending, grouping, and specifying external contextual factors based on the categories identified above. Relationships with the main TAM components are also proposed. Fig. 5 illustrates the research model.

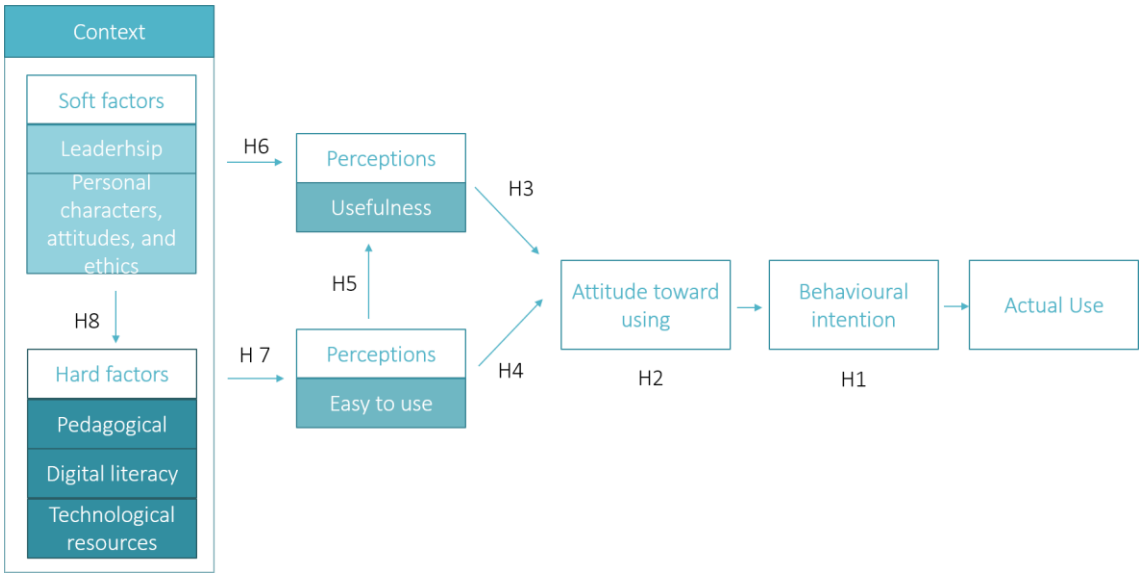


Fig. 5 The research mobile adoption, adapted from the technology acceptance model (Davis, 1989)

The hypothesis derived from the model are detail in Appendix D.

Of the nine studies included in the systematic review that used the TAM model, only one reveals nonpositive results in one of the hypotheses analyzed: H3 (Hamidi and Chavoshi 2018). Table 6 shows the results of the hypotheses used in the studies, the size of the samples and the country of origin of the main author.

Table 6 Results of hypotheses about factors that affect mobile learning

Hypothesis	Study	Result	Sample Size	Country
H1	(Gao et al. 2011)	Supported	25	United States
	(Hamidi and Chavoshi 2018)	Supported	300	Iran
	(Y. Liu et al. 2009)	Supported	209	Finland
	(Lu and Viehland 2008)	Supported	180	New Zealand
	(Sabah 2016)	Supported	80	Finland
	(Yadegaridehkordi et al. 2013)	Supported	350	France
	(Yeap et al. 2016)	Supported	900	Malaysia
H2	(Hamidi and Chavoshi 2018)	Supported	300	Iran
	(Lu and Viehland 2008)	Supported	180	New Zealand
	(Yadegaridehkordi et al. 2013)	Supported	350	France
	(Yeap et al. 2016)	Supported	900	Malaysia
H3	(Gao et al. 2011)	Supported	25	United States
	(Hamidi and Chavoshi 2018)	Insignificant	300	Iran
	(Hao et al. 2017)	Supported	292	China
	(Y. Liu et al. 2009)	Supported	209	Finland
	(Lu and Viehland 2008)	Supported	180	New Zealand
	(Sabah 2016)	Supported	80	Finland
	(Sarrab et al. 2016)	Supported	806	Palestine
	(Yadegaridehkordi et al. 2013)	Supported	350	France
	(Yeap et al. 2016)	Supported	900	Malaysia
H4	(Gao et al. 2011)	Supported	25	United States
	(Hamidi and Chavoshi 2018)	Supported	300	Iran

	(Hao et al. 2017)	Supported	292	China
	(Y. Liu et al. 2009)	Supported	209	Finland
	(Lu and Viehland 2008)	Supported	180	New Zealand
	(Sabah 2016)	Supported	80	Finland
	(Sarrab et al. 2016)	Supported	806	Palestine
	(Yadegaridehkordi et al. 2013)	Supported	350	France
	(Yeap et al. 2016)	Supported	900	Malaysia
H5	(Hamidi and Chavoshi 2018)	Supported	300	Iran
	(Y. Liu et al. 2009)	Supported	209	Finland
H6	(Gao et al. 2011)	Supported	25	United States
	(Hamidi and Chavoshi 2018)	Supported	300	Iran
H7	(Gao et al. 2011)	Supported	25	United States
	(Hamidi and Chavoshi 2018)	Supported	300	Iran

3.3 Key success factors for the adoption of mobile learning in Catalonia

To carry out the case study in Catalonia n expert judgment was carried out with the double objective of validating the previous results and investigating the importance of factors affecting mobile learning in Catalonia.

Participants were provided with a dossier that included the following sections: introduction; expert judgement goals; definition of the 5 key groups of factors impacting mobile learning identified above and summarized in Table 5; and a detail of 50 specific factors to classify into different categories, together with a glossary of said factors. Appendix C reproduces the dossier provided to the experts in English and Catalan.

To validate the categories identified above by the participants in the expert meeting, the researchers presented the 5 categories with a brief description. The participants validated the categories. Then, the participants were asked to prioritize the five categories of factors described above, using a Likert-type scale. The mean and standard deviation of each of the scales are illustrated by the group of experts in Table 7. Overall, participants prioritize the five categories from the most challenging to the lowest impact as follows: leadership; personal character, attitudes, and ethics; digital literacy; pedagogical; and technological resources. Fig. 6 visualizes and arranges the experts' priorities as a spider's web.

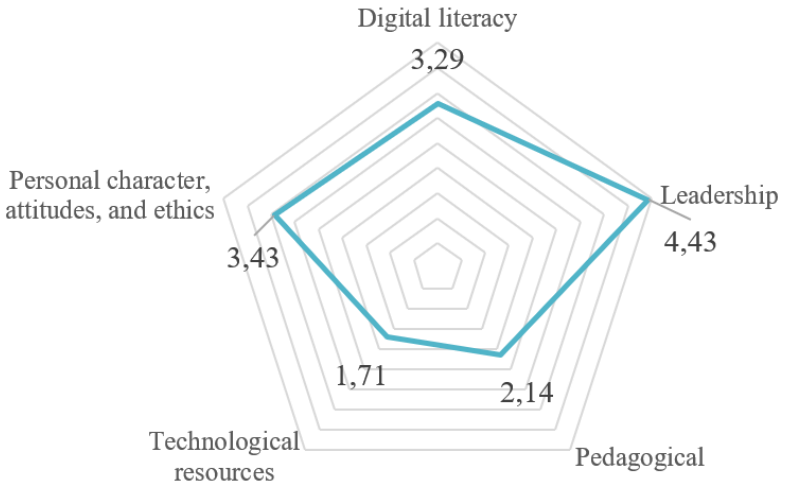


Fig. 6 Prioritization by expert judgement of the categories of factors affecting mobile learning adoption

A specific recurrent factor in relation to leadership was the importance of collaboration. In general, neither school leaders, university experts nor inspectors felt that technological resources are a substantial obstacle to the adoption of mobile learning. Most of them (60%) rated it as the least relevant category.

The greatest difference between inspectors and university experts concerned the pedagogical factors. University experts considered this category to be the second most significant, whereas inspectors viewed it as least significant.

Table 7 Prioritization of categories affecting mobile learning perceived by experts

Category of factors	Inspectors' mean (*SD*)	School leaders' mean (*SD*)	University experts' mean (*SD*)	Mean (*SD*)
Personal character, attitudes, and ethics	3.00 (1.41)	3.50 (0.71)	3.67 (1.15)	3.43 (0.98)
Leadership	5.00 (0.00)	5.00 (0.00)	3.67 (1.53)	4.43 (1.13)
Technological resources	1.50 (0.71)	2.50 (2.12)	1.33 (0.58)	1.71 (1.11)
Pedagogical	3.00 (0.00)	1.50 (0.71)	2.00 (1.00)	2.14 (0.90)
Digital literacy	2.50 (2.12)	2.50 (0.71)	4.33 (0.58)	3.29 (1.38)

The correlation coefficients are all positive and significantly high in the case of university experts and inspectors. Table 8 depicts the Pearson correlation coefficient among groups of participants.

Table 8 Pearson correlation coefficient among groups of participants

	University expert	Inspector	School leader

University expert	1		
Inspector	0.741249317	1	
School leader	0.489274892	0.496291667	1

During the next phase of the meeting, the experts were given a list of 50 specific factors and asked to classify them in the different categories previously analyzed. The factors were presented randomly and sorted according to alphabetical order in Catalan. All factors were selected at least once by one of the participants. Some participants selected the same factor in more than one category. Table 9 shows the 50 factors grouped by category of participants and the number of times they were selected.

Table 9 Key factors that affect mobile learning according to relevance

	# factor	Inspector (n=2)	School leader (n=3)	University expert (n=2)	Total (n=7)
Teacher's open minds (B. H. Khan 2005)	40	6	4	2	12
Type and quality of student assessment (Volery and Lord 2000)	46	6	3	3	12
Resources plan (Fresen & Lesley, 2006)	29	2	4	4	10
Organizational capacity (Orcutt and AlKadri 2009)	6	1	4	5	10
Clear guidelines and framework (B. H. Khan 2005)	32	4	4	2	10
Credibility (Kouzes and Posner 2011)	15	1	4	5	10
Lack of clear vision and mission (Ekberg and Gao 2018)	50	2	3	5	10
Culture (Goyal et al. 2010; Heide et al. 2002; Moses 2017; Paroutis and Heracleous 2013)	30	1	3	5	9
Trust in technology (Ekberg and Gao 2018)	41	1	4	4	9
Enthusiastic teachers (Fresen & Lesley, 2006)	24	4	4	1	9
Resistance to change (Orcutt and AlKadri 2009)	48	2	3	4	9
Knowledge construction (Hao et al. 2017)	14	3	3	3	9
Group learning (Fresen & Lesley, 2006)	31	4	3	2	9
Teachers' digital competences (Bocconi et al. 2013)	9	2	3	3	8
E-learning mindset (Fresen & Lesley, 2006)	39	3	2	3	8
Navigation (B. H. Khan 2005)	1	2	3	2	7
Commitment (Goyal et al. 2010)	10	3	2	2	7
Frequent and constructive feedback to students (Ng and Nicholas 2013)	26	2	4	1	7
Learning strategies (Goyal et al. 2010)	22	2	2	3	7
Content readiness (Fresen & Lesley, 2006)	17	3	2	1	6
Software (Olafsen and Cetindamar 2005)	20	2	3	1	6
Communication (Gronn 1983; Hackman and Johnson 2013; B. H. Khan 2005; Moses 2017; Ng and Nicholas 2013)	11	2	2	2	6
Device (Soong et al. 2001)	19	2	3	1	6
Better collaboration using online distribution boards (Soong et al. 2001)	8	1	3	2	6

Reluctance to use mobile devices for educational purposes (Fresen & Lesley, 2006)	47	1	2	3	6
Effective training (Ekberg and Gao 2018)	27	3	1	2	6
Maintain teachers' and student's knowledge skills (Goyal et al. 2010)	38	3	3	0	6
Assessing student learning (Woolf 2010)	5	0	3	2	5
Instructor technical competence (B. H. Khan 2005)	18	2	2	1	5
Availability of educational software (Soong et al. 2001)	16	0	4	1	5
Expectations of efficiency and effectiveness (Yoo et al. 2012)	25	1	1	3	5
Conflict and negotiations (B. H. Khan 2005)	13	1	2	2	5
Personality traits (Fresen & Lesley, 2006)	7	1	3	1	5
Accessibility (Alrasheedi and Capretz 2015; B. H. Khan 2005)	2	1	2	2	5
Classroom interaction (B. H. Khan 2005)	35	2	1	1	4
Distribute responsibility (Eide and Søreide 2014)	21	2	1	1	4
Lack of incentives (Mercader 2018)	33	1	2	1	4
Malfunctioning IT (Ekberg and Gao 2018)	37	1	2	1	4
Strategy formulation (Goyal et al. 2010)	28	1	2	1	4
Teaching practices predefined (Mercader 2018)	45	0	1	2	3
Student participation (Goyal et al. 2010)	43	1	2	0	3
Usability (B. H. Khan 2005)	49	1	1	1	3
Adaptability of the course to being taught through ICT (Soong et al. 2001)	3	1	0	2	3
Personalizing education (Woolf 2010)	44	1	2	0	3
Level of interaction (Rikala 2015)	42	1	1	1	3
Curriculum (Rikala 2015)	36	1	1	0	2
Affordability (UNESCO, 2011)	4	1	0	1	2
Key Performance Indicators (Humaidi et al. 2010)	34	1	1	0	2
Connectivity (Alrasheedi and Capretz 2015)	23	1	1	0	2
Extrinsic motivators: facilitating conditions (B. H. Khan 2005)	12	0	0	1	1
Total		90	116	96	302

The participants agreed on the classification of at least three factors per category. Table 10 shows the three most frequently included factors in each of the five categories.

Table 10 Key factors that affect mobile learning grouped into categories

Category	Item
Technological resources	Navigation (Khan, 2005)
	Software (Olafsen & Cetindamar, 2005)
	Device (Soong, Chan, Chua, & Loh, 2001)
Pedagogical	Credibility (Kouzes & Posner, 2011)
	Learning strategies (Goyal et al., 2010)
	Type and quality of student assessment (Volery & Lord, 2000)
Digital literacy	Type and quality of student assessment (Volery & Lord, 2000)
	Teachers digital competences (Bocconi, Kampylis, & Punie, 2013)

	Credibility (Kouzes & Posner, 2011)
Personal character, attitudes, and ethics	Teacher's open minds (Khan, 2005)
	Resistance to change (Orcutt & AlKadri, 2009)
	Enthusiastic teachers (Fresen & Lesley, 2006)
Leadership	Clear guidelines and framework (Khan, 2005)
	Organizational capacity (Orcutt & AlKadri, 2009)
	Culture (Goyal et al., 2010; Heide, Grønhaug, & Johannessen, 2002; Moses, 2017; Paroutis & Heracleous, 2013)

For the rest of the factors, in the case of discrepancies, the category selected by most participants was used. The Venn diagram illustrated in Fig. 7 shows the classification of the above critical success factors affecting mobile learning according to the criteria of the panel of experts. The coding of the factors is the one used in Table 9. The size of the elements of the Venn diagram represents the prioritization of the different categories represented in Fig. 6. The color scheme distinguishes the soft and hard categories. The categories in red are soft, and the categories in blue are hard.

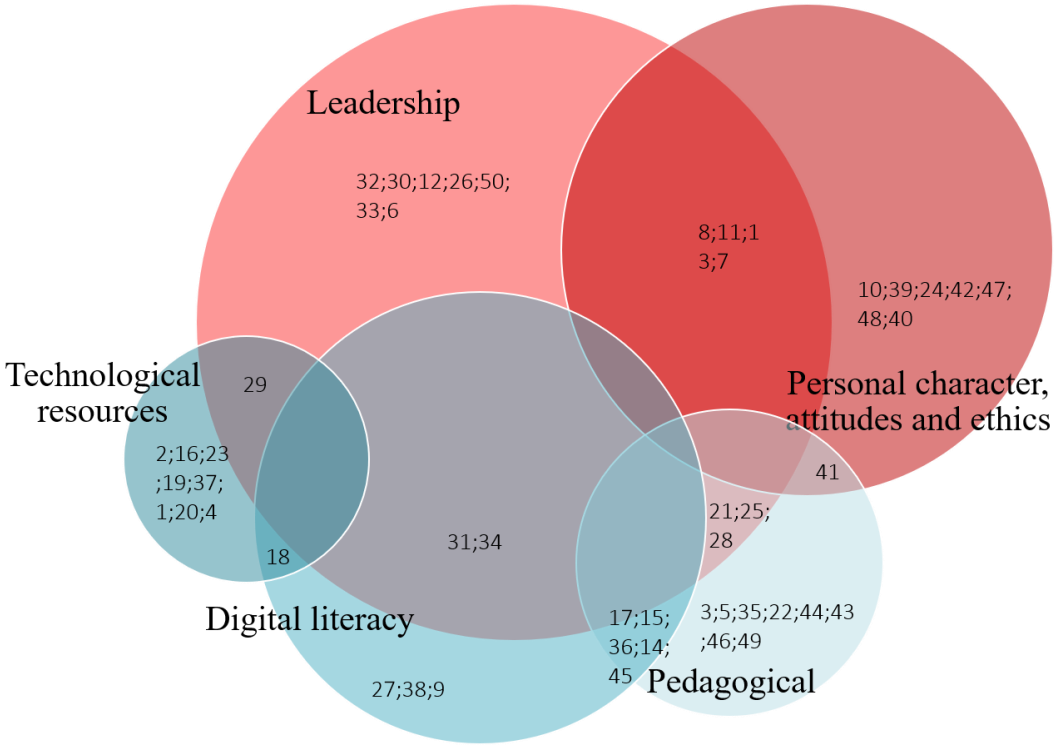


Fig. 7 Classification of key factors affecting mobile learning adoption in Catalonia

To identify more qualitative impacts of the mobile learning intervention described in this paper, comments from experts were analyzed. One inspector stated: “without evaluation, there are no results”. Nationals Spain policies 1:1 was specified in most of Spain's territories through the «School 2.0» program and was cited as an example of the

low relevance of technological resources. Experts highlighted the fact that the project was mainly focused on technological resources, disregarding other crucial aspects. Additionally, participants commented about the poor quality of resources, mentioning that electronic textbooks were often simply the digital versions of existing print products. These results are consistent with the results from the 1 to 1 Learning study collected by European Schoolnet (EUN) through its network of policymakers, researchers and practitioners from 30 Ministries of Education in Europe (Bocconi et al. 2013).

Another general comment was related to the difficulty of analyzing isolating factors due to the high correlation between them. School leaders highlighted the challenges of adjusting the different levels of technological knowledge among teachers.

The ethical repercussions were among the aspects that were most emphasized by the school leaders. One of them had gone to three trials for three cyber-bullying lawsuits. All the experts agreed on the double need to regulate and limit the use of mobile devices in the classroom from an ethical point of view, such as the importance of having legal support departments.

3 Discussion

Despite the vast literature demonstrating the positive results of the adoption of mobile learning in the processes of teaching and learning, numerous studies have concluded that its use is not optimized (Alrasheedi and Capretz 2015; Kopcha 2012; Niemi et al. 2013; Nikolopoulou and Gialamas 2016; Rikala 2015; Stevenson et al. 2015). Sustainability and efficiency are challenges for mobile learning adoption (Sutton & DeSantis, 2017). This perspective coincides with our findings.

There are multiple studies analyzing the factors that affect the integration of technologies in education. A total of 361 different factors were identified in our analysis. However, there are fewer studies aimed at grouping and classifying these factors. No categorization of factors affecting adoption of mobile learning has been identified that groups the factors into soft and hard, a fundamental division that is widely used in other fields such as management (Dewar et al. 2011; Guohui and Eppler 2008; Higgins 2005; Humaidi et al. 2010; Peters and Waterman 2006).

This study refers to categorizations of the field of strategic management and jointly with the review of the main categories of factors that affect the adoption of mobile learning, provides a new categorization. The main contribution of this study is the

identification of critical success factors influencing mobile learning in education and the proposal of a hierarchical categorization. The categorization offered by this study is based on previously identified and tested factors. This study provides a taxonomy to categorize and orchestrate the factors affecting the adoption of mobile learning providing a holistic and coherent vision. This categorization contributes to improving sustainability in the adoption of mobile learning since it is consistent with the model developed by Cisler (2002) and completed by Ng and Nicholas (2018) that based the sustainability of ICT in education on five elements: economic, social, political, technological, and pedagogical.

Findings from this study have significant implications for future work. This new categorization is expected to help minimize barriers and optimize the mobile learning adoption process and help institutions to plan and evaluate efficient mobile learning adoption.

4 Conclusions

The purpose of this study was to conduct an analysis of the factors that affect most mobile learning adoption. The study employed different methodologies to gather evidence to answer each of the below research questions:

RQ1: What are the critical success factors for the adoption and sustainable use of mobile learning in education? In total, 361 factors have been identified.

RQ2: How can the key factors affecting mobile learning be grouped in a hierarchical taxonomy in the education context? Factors affecting mobile learning adoption were initially grouped into two major categories based on a dimension that mediates the tangibility of the factors: hard and soft.

The hard category refers to those factors that impact the learning process in a way that the institutions could manage and measure in a reasonable way. This group includes three categories of factors: technological resources, digital literacy, and pedagogical factors. On the other hand, the soft categories are those that mainly affect the soul and the people of the institutions. Two categories can be derived from this group: leadership and personal character, attitudes, and ethics.

RQ3: What categories of success factors are given more importance?

The results reveal that the soft categories are more relevant when adopting mobile learning than hard ones. Leadership has been identified prominently as the crucial category. Within the hard categories, pedagogy has stood out in digital literacy, while the

technological resources category has had the least relevant assessment. Among the different groups of participants, namely, inspectors, school leaders and university experts, there have been no significant discrepancies in relation to the most and least relevant categories. Fig. 8 shows the classification and specific weight of the critical success factors affecting mobile learning adoption in Catalonia.

One of the limitations is the lack of approaches of other participants, especially teachers and students. In the future, it would be very interesting to be able to use quasi-experimental techniques to validate the results at the methodological level. There is a need of a more in-depth perspective of the categorization to guarantee the generalization of results. Going forward, it would be beneficial for researchers to contextualize the categories in various educational contexts to see if there is anything that has been omitted that needs to be added. Also, the current findings are likely to change with ongoing technological developments.

Future studies might confirm the proposed classification as well as identify indicators to measure the impact.

Compliance with Ethical Standards

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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